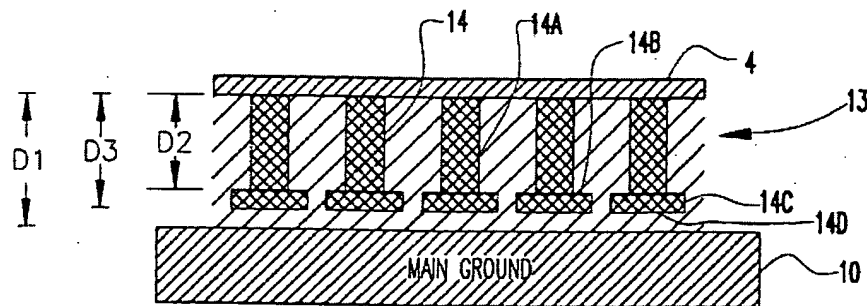


Waffle-Iron Waveguide Filter: (a) view looking into port 2, (b) exploded view.

FIG. 1



Examples of resonant vias from Riad's US patent 5,886,597.

FIG. 2

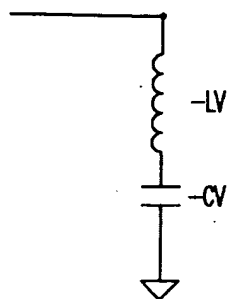






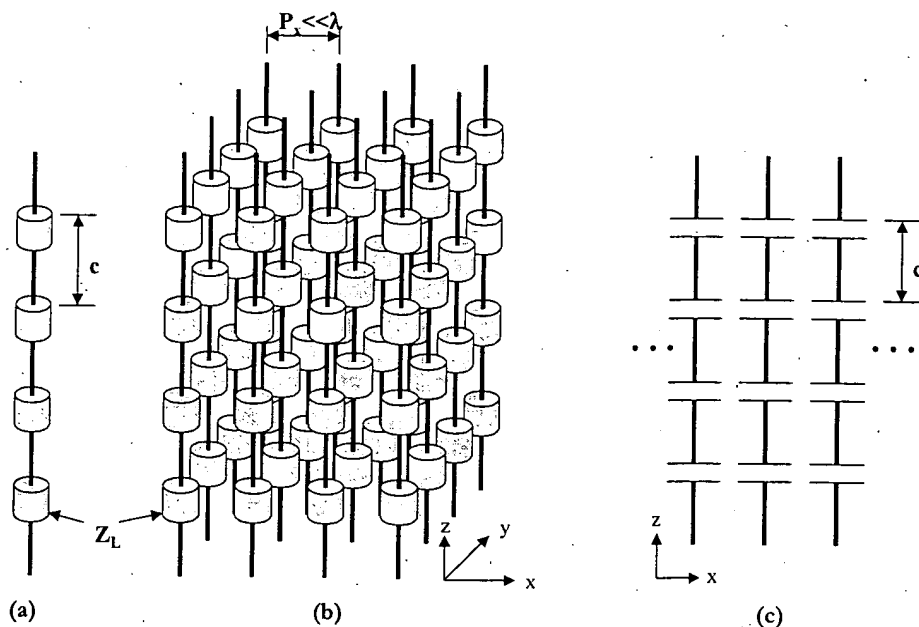


FIG. 3

| | Mechanically-Unbalanced | Mechanically-Balanced |
|----------|---|--|
| Internal | Internal "T"  US Pat. 5,886,597 | Internal "double T"  US Pat. 6,542,342 Internal "I"  |
| External | External "T"  US Pat. 5,886,597 | External "I"  |
| Hybrid | | Hybrid "I"  |

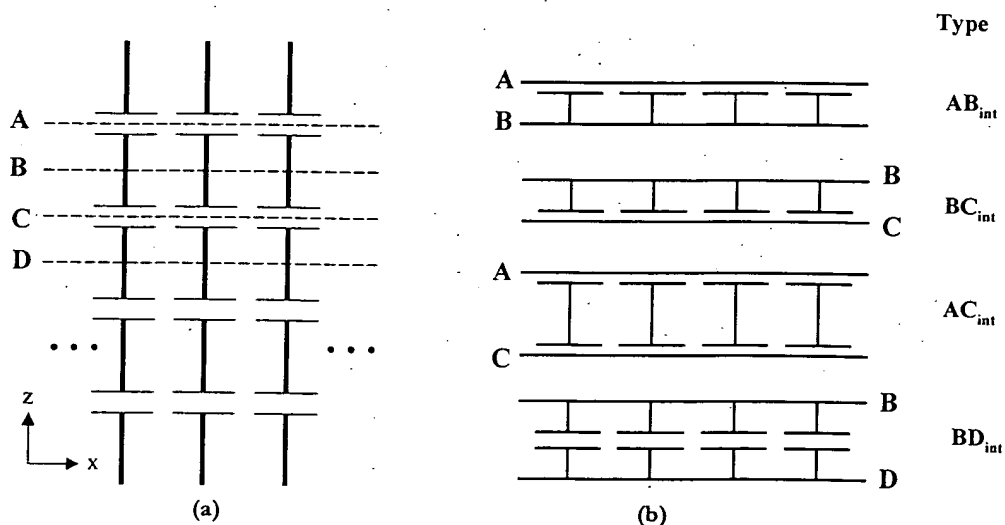
Examples of resonant vias. Dielectric layers required for support are not shown.

FIG. 4



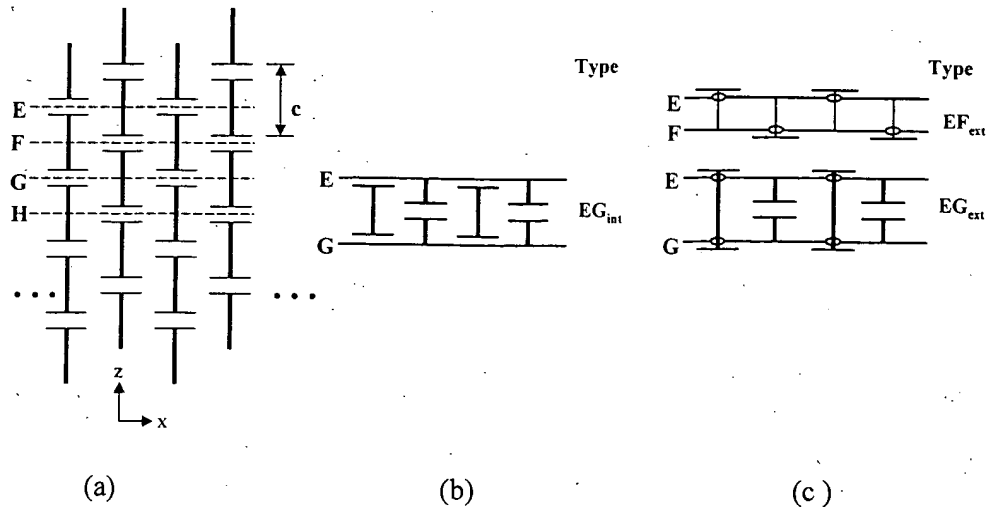
The starting point for the derivation of new inventions is the loaded wire media: (a) a single wire with uniform periodic series loads, (b) a rectangular array of loaded wires, (c) loads are now defined as parallel-plate capacitors.

FIG. 5



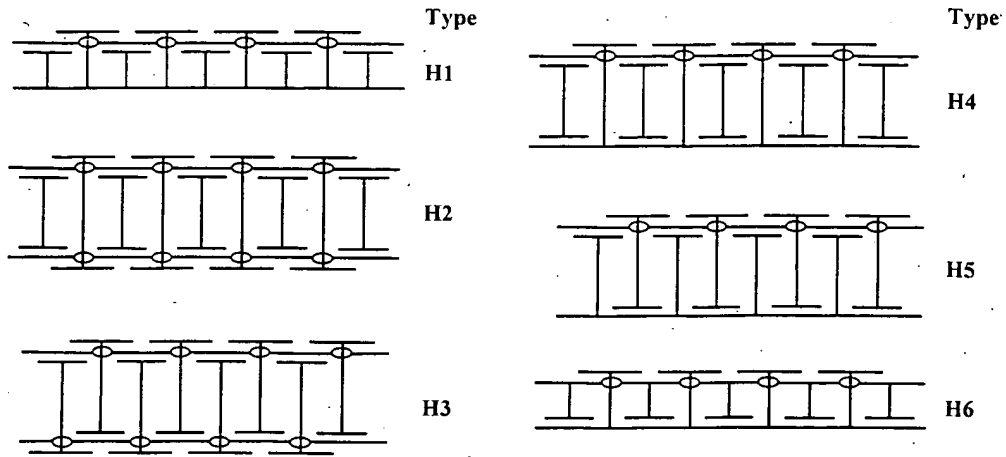
Exploit the planes of physical symmetry to obtain electromagnetically equivalent structures: (a) the infinite wire media, (b) PPW structures of finite height. The supporting dielectric structure is not shown.

FIG. 6



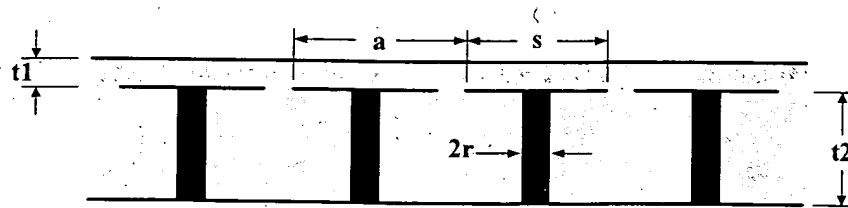
Alternative embodiments of PPW stop band filters: (a) Capacitive-loaded infinite wire media, (b) a PPW filter of finite height using internal capacitors, (c) PPW filters of finite height using external capacitors. The supporting dielectric structure is not shown.

FIG. 7



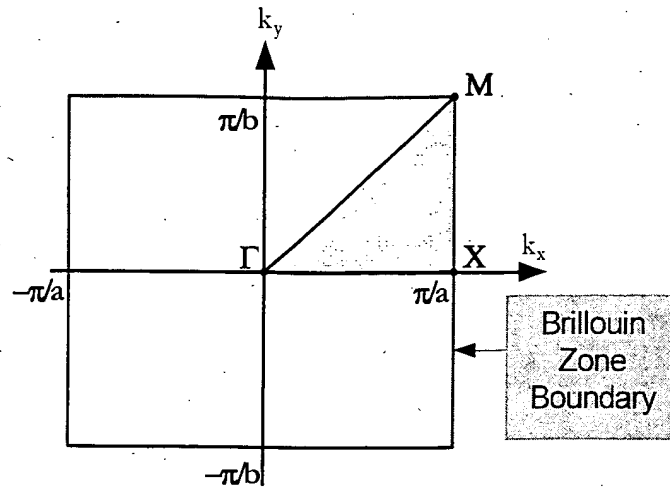
Hybrid embodiments include combined internal and external capacitive loads. Dielectric cores are omitted for clarity.

FIG. 8



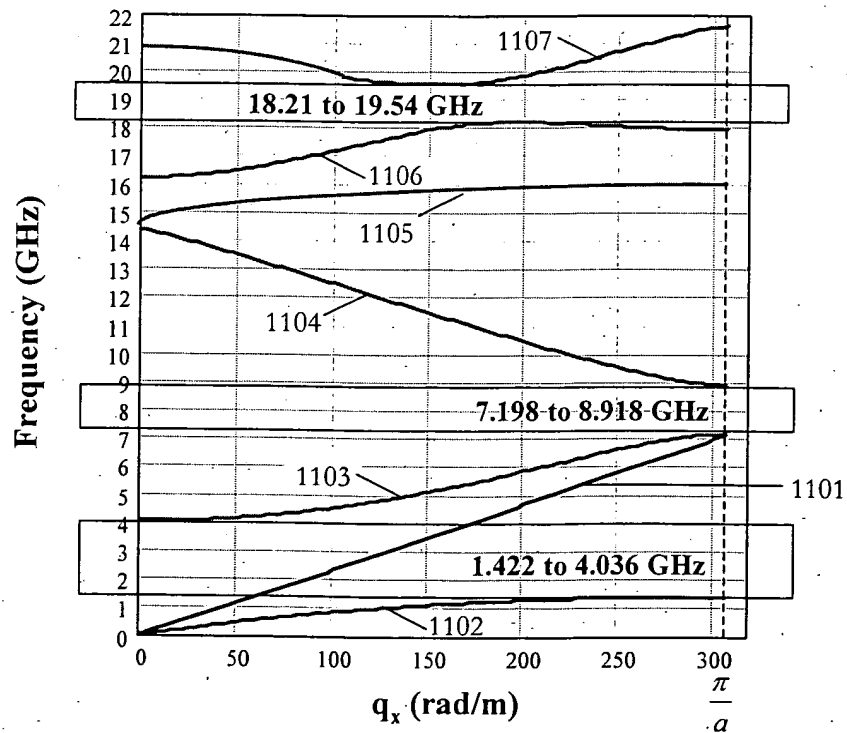
Elevation view of a square lattice of internal T resonant vias.

FIG. 9



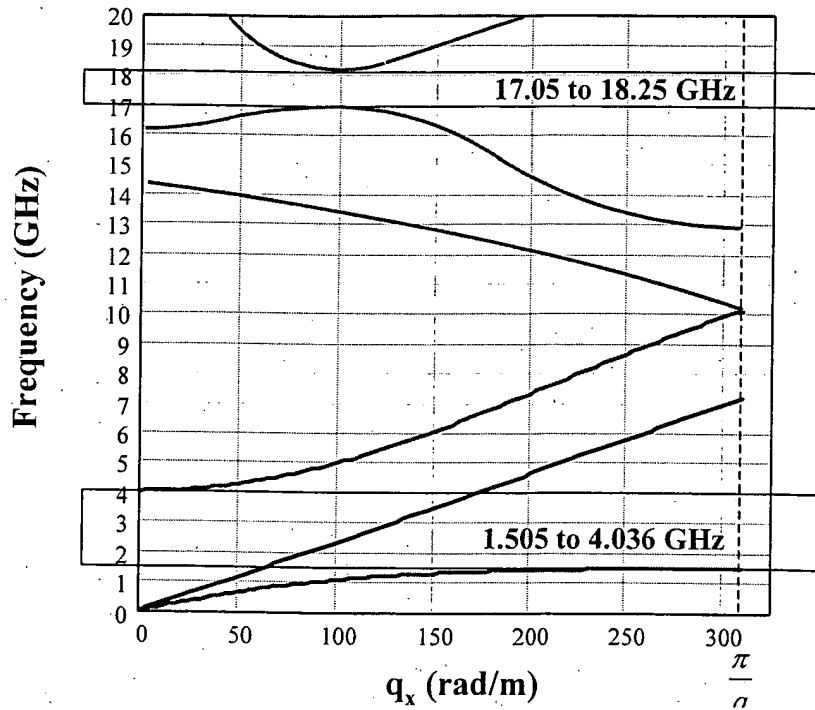
Brillouin zone for a 2D periodic structure with a rectangular lattice of unit cell dimensions $a \times b$ in Cartesian coordinates.

FIG. 10



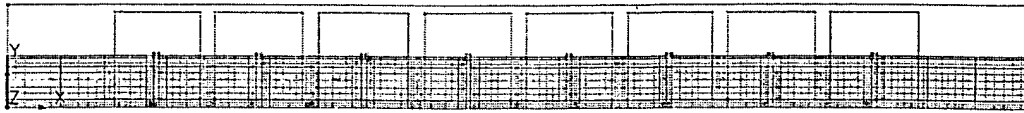
Dispersion diagram along the ΓX line for the capacitive-loaded wire media corresponding to the array of resonant vias shown in Figure 9. The stop bands are bracketed.

FIG. 11

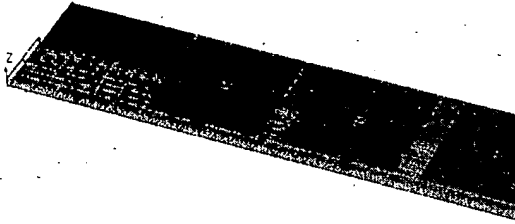


Dispersion diagram along the ΓM line for the capacitive-loaded wire media corresponding to the array of resonant vias shown in Figure 9. The stop bands are bracketed.

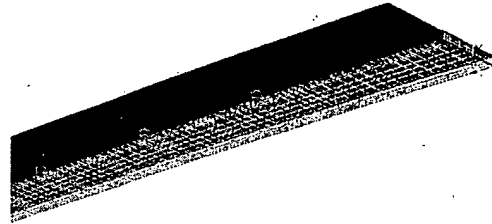
FIG. 12



(a)



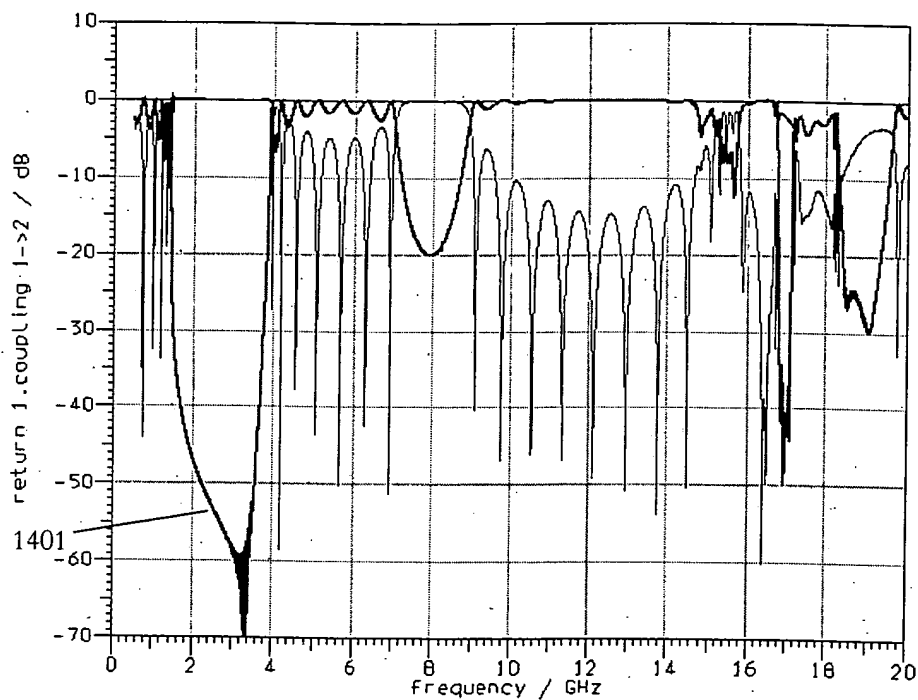
(b)



(c)

Geometry for the simulation of the resonant via array shown in Figure 9: (a) plan view showing all 8 cascaded unit cells, (b) top view with upper plate hidden, (c) bottom view with the lower plate hidden.

FIG. 13



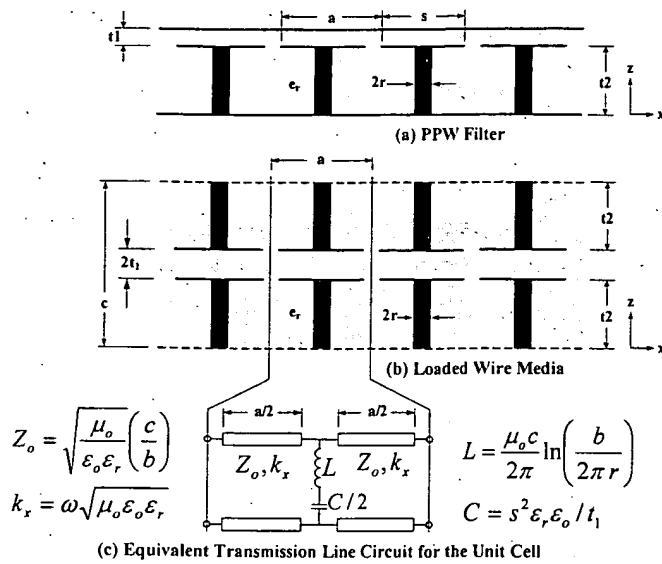
Transmission response for a TEM mode propagating in the x direction through the stop band filter shown in Figure 9. A -10 - dB stop band is shown from 1.4 GHz to 3.9 GHz, a ratio of 2.78:1.

FIG. 14

| Stopband | Microstripes | | Eigenvalue Solution | |
|-------------|-----------------|-----------------|---------------------|-----------------|
| | Lower Band Edge | Upper Band Edge | Lower Band Edge | Upper Band Edge |
| | (GHz) | (GHz) | (GHz) | (GHz) |
| Fundamental | 1.401 | 3.906 | 1.422 | 4.036 |
| Secondary | 7.07 | 8.85 | 7.198 | 8.918 |
| Tertiary | 18.28 | 19.62 | 18.21 | 19.54 |

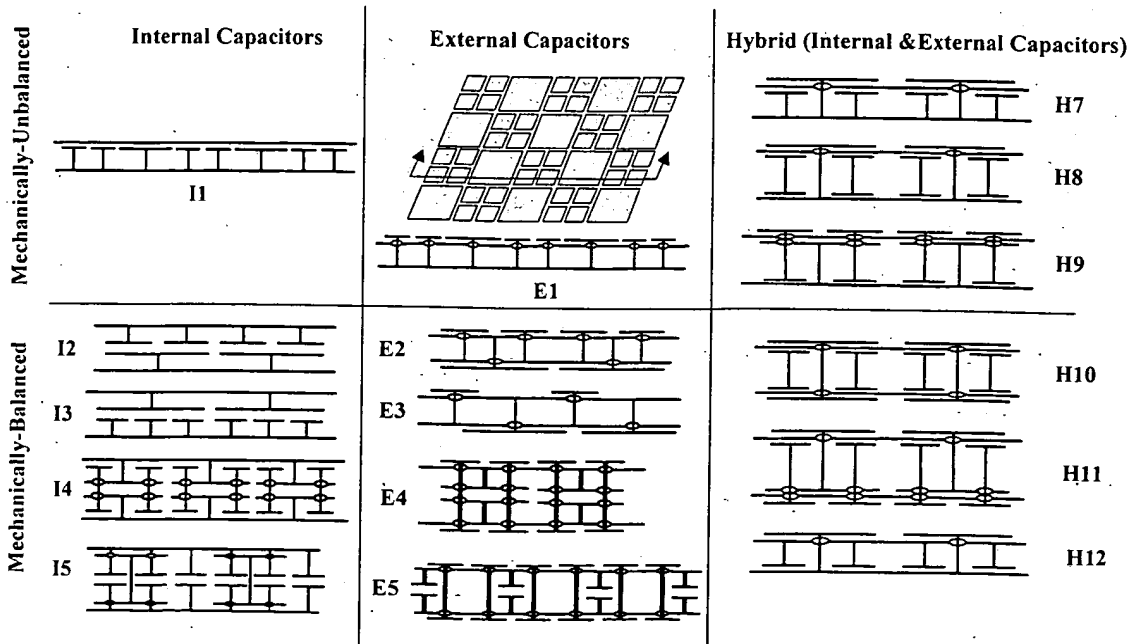
Comparison of stop band frequencies for the PPW filter shown in Figure 9.

FIG. 15



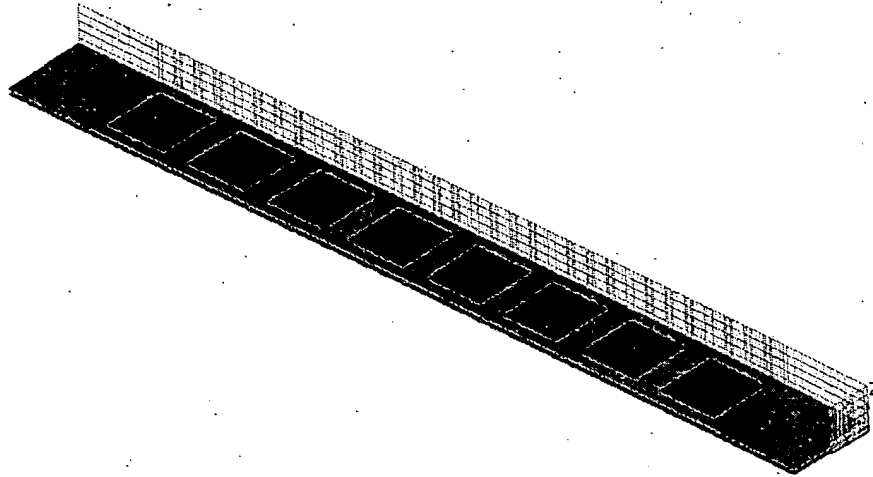
At lower frequencies around the first stop band, wave propagation along a principal axis, such as the x-axis, can be modeled using a simple transmission line circuit model.

FIG. 16

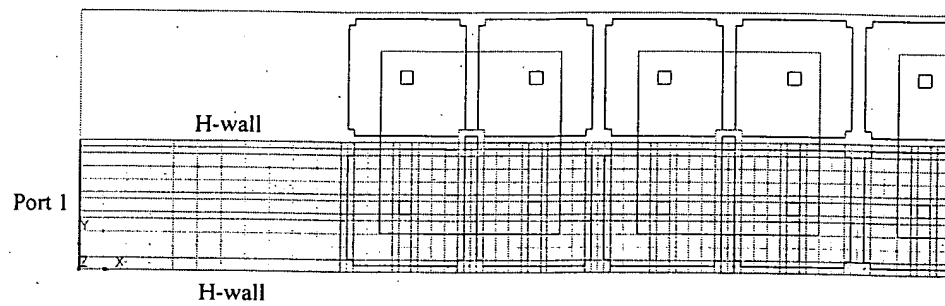


Examples of resonant via arrays with commensurate periods. Each is a PPW stoop band filter.

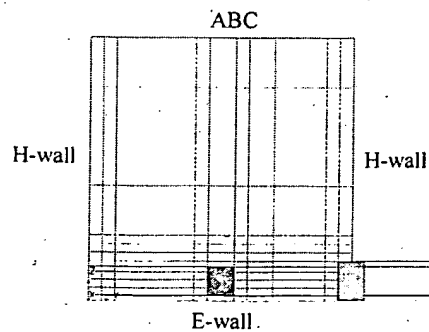
FIG. 17



(a)



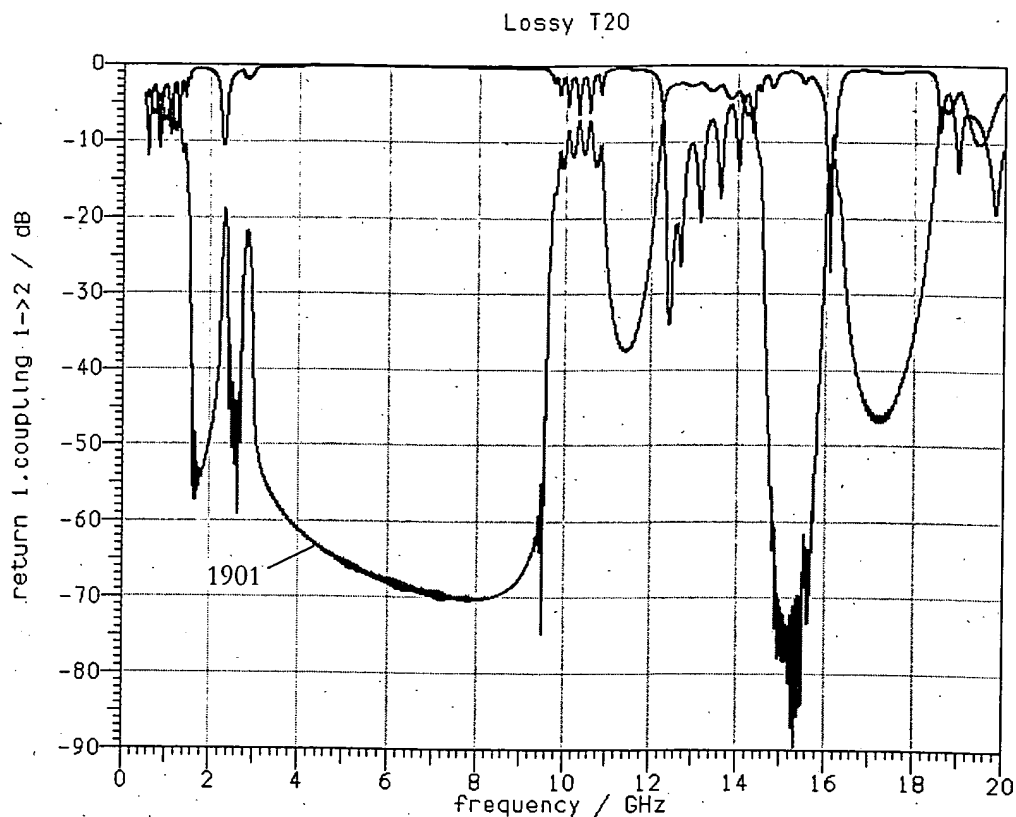
(b)



(c)

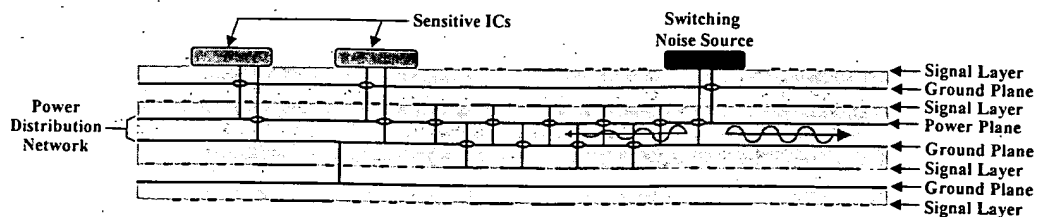
Geometry for the simulation of a commensurate period resonant via array of type H12: (a) perspective view showing all 8-cascaded unit cells, (b) plan view, (c) elevation view. Hidden are the dielectric cores in (a), (b) and (c).

FIG. 18



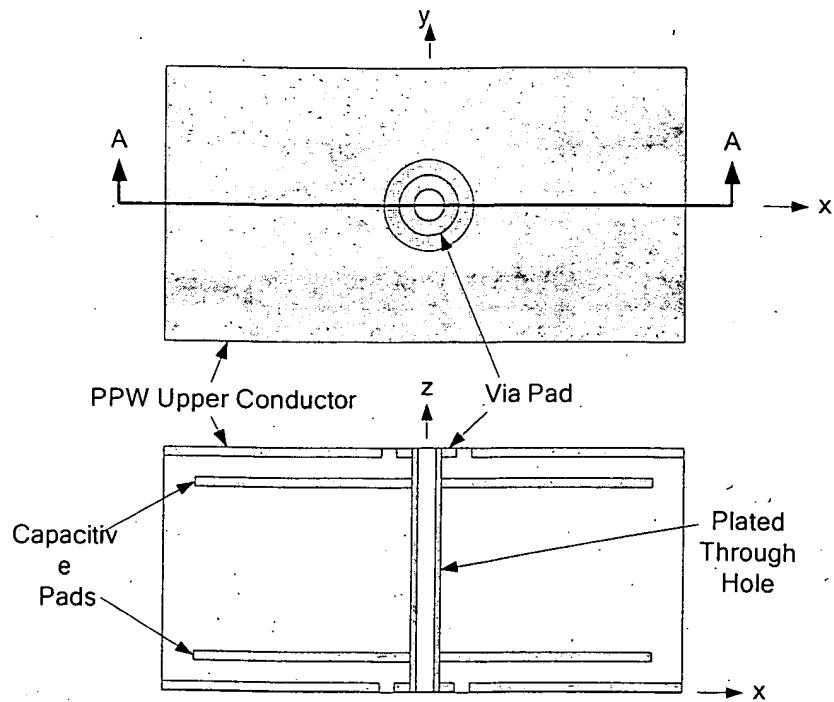
Transmission response (1901) for a TEM mode propagating in the x direction through the stop band filter shown in Figure 18. A -10 dB stop band is shown from 1.33 GHz to 10.0 GHz, a 7.5:1 ratio.

FIG. 19



Stop band filter embodiment EF_{ext} is well suited for integration into existing PWB designs since it requires neither additional metal layers nor any additional thickness.

FIG. 20



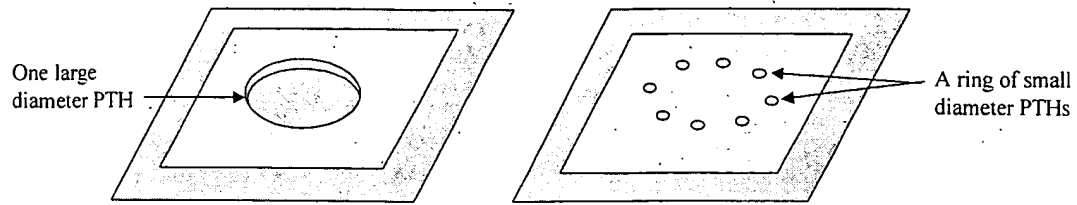
Plated through holes may be used in the fabrication of resonant vias as illustrated here for an internal I resonant via.

FIG. 21

| | Mechanically-Unbalanced | Mechanically-Balanced |
|----------|-------------------------|-----------------------|
| Internal | Internal "T" | Internal "double T" |
| External | External "T" | External "I" |
| Hybrid | | Hybrid "I" |

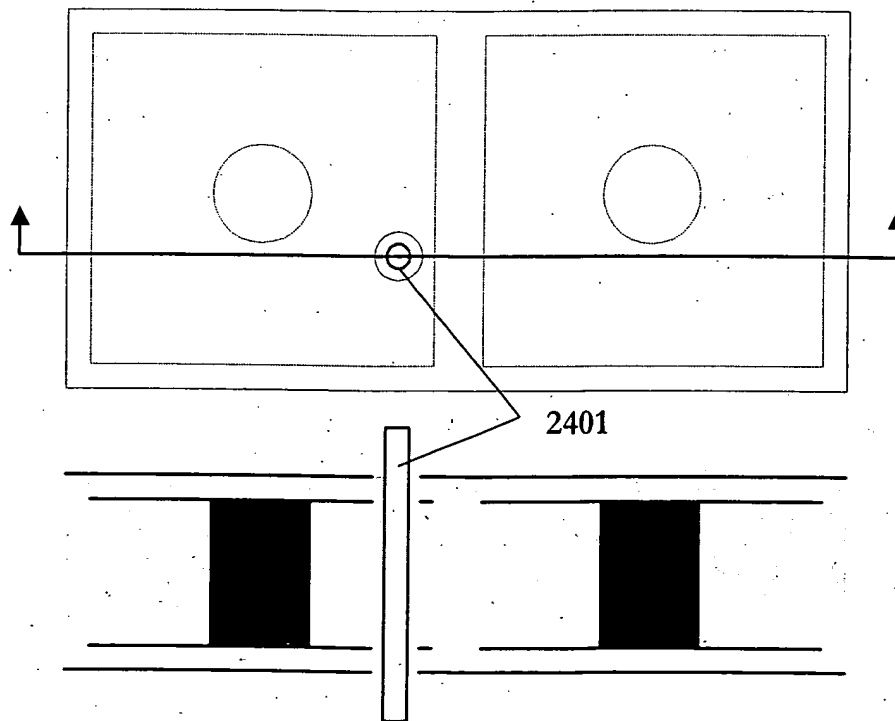
Examples of fundamental resonant cluster via types consisting of two or more vias connected in parallel.. Dielectric layers required for support are not shown.

FIG. 22



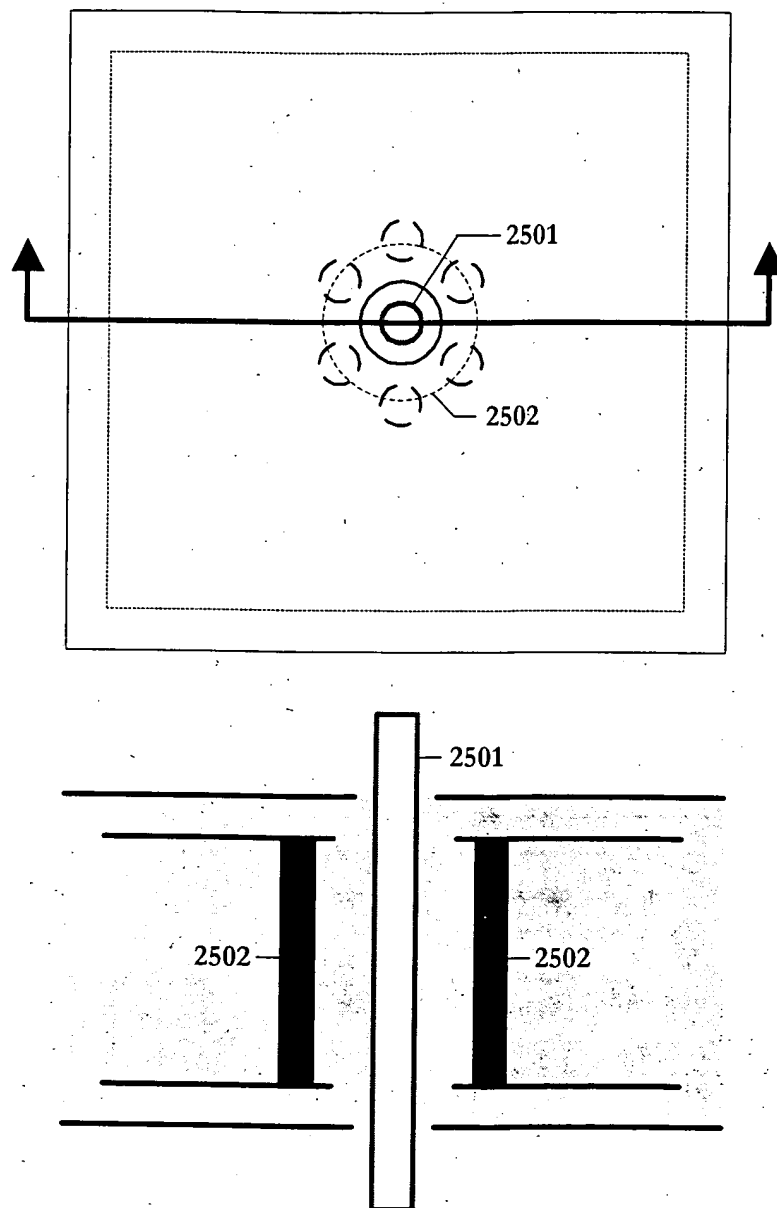
Comparison of effective parallel-plate areas available for one large diameter via compared to an electrically equivalent cluster via comprising a ring of 8 smaller diameter vias.

FIG. 23



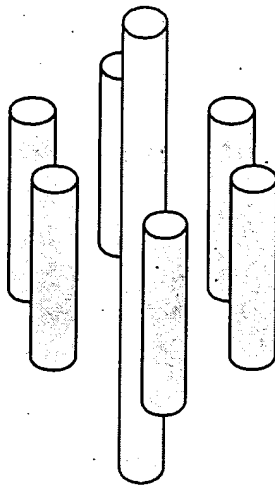
Pair of resonant vias showing signal via passing through the PPW.

FIG. 24



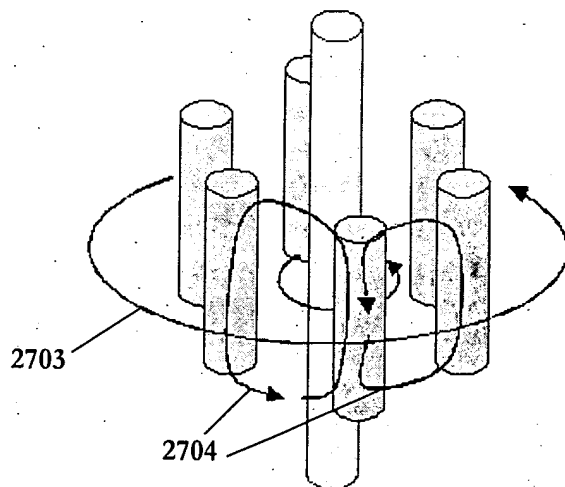
Plan and elevation cross-sections of exemplary cluster via with interior signal via.

FIG. 25



Cluster via with interior signal via as in FIG. 25.

FIG. 26



Faraday cage formed by cluster of vias as in FIG 24.

FIG. 27